This invention has relation to devices for drilling and forming a straight drill hole, or for strengthening a hole which has previously been drilled.

In my prior application, Serial Number 414,072, filed December 14, 1929, I have described a straight hole device which embodies a stiff tubular member surrounding a drill stem or drill pipe for some considerable length, and located on the drill pipe near the drilling bit, and having associated with it a reamer or reamers for rounding out the hole which has been drilled by the bit.

The present invention partakes of the general nature of my said previous invention, and it is among the objects of the present invention to provide a structural form for the element which I generally designate as a guide tube, which structural form may, with slight variations or with interchange of parts, be used either as a guide tube, as an associated reamer, or as a combined guide device and reamer. The accomplishment of these and other objects will be best understood from a consideration of the following detailed and specific description of preferred and illustrative embodiments of the invention, reference for this purpose being had to the accompanying drawings, in which:

Figure 1 is an elevation showing the lower part of one assembly embodying my invention;
Fig. 2 is a similar view showing the upper part of such assembly;
Fig. 3 is an enlarged detail of the upper part of the guide tube device, the view being partially in elevation and partially in section;
Fig. 4 is a cross-section on line 4—4 of Fig. 3;
Fig. 5 is an enlarged detail, partly in elevation and partly in longitudinal section, showing the construction of the lower reamer included in the assembly of Fig. 1;
Fig. 6 is a cross-section on line 6—6 of Fig. 5;
Fig. 7 is an elevation showing a typical variant form of my invention constituting a combined guide device and reamer; and
Fig. 8 is an enlarged cross-section on line 8—8 of Fig. 7.

Referring first to the form of assembly shown in Figs. 1 and 2, and to the detail views of Figs. 3 to 6 inclusive; the drill pipe or drill stem is indicated at 10, an upper reamer is indicated at 11, the intermediate guide device is designated generally by the numeral 12, a lower reamer is shown generally at 13, and the drill bit is illustrated at 14. All these several elements are coupled together longitudinally, and preferably immediately adjacent to each other, as is indicated in Figs. 1 and 2. The lower end of the drill pipe proper, shown at 10, is coupled at 20 to the upper end of reamer 11. The lower end of this reamer 11 is coupled at 21 (see the upper part of Fig. 3 for the detail) to the upper end of the drill pipe section 22, which extends longitudinally through the guide device 12. At the lower end this section 22 of the drill pipe has a tool joint member 23 directly coupled with the tool joint member 24 at the upper end of the lower reamer 13, shown in detail in Fig. 5. And the lower end of this lower reamer 13 is coupled directly at 25 with the drill bit 14. It will be understood that when the whole assembled device is being used for initial drilling of a hole, the drill bit 14 performs the usual drilling office, and the hole is drilled, kept straight, and reamed out round, in a single operation. If a previously drilled hole is being reamed out and straightened, the drill bit 14 may not necessarily be used; or, if used, performs merely the function of an entering guide for the assembly, and of keeping circulating fluid stirred up below the reamers. Circulating fluid is fed to the drill through the hollow drill pipe and through the hollow interiors of the reaming elements (shown typically in detail in Fig. 5) and through the drill pipe section 22 which extends through the length of guide device 12.

Explaining first the preferred nature and structure of the guide device I refer to Figs. 1 to 4. A longitudinal tube 30 surrounds the drill pipe section 22. This tube 30 is of a suitable length so that its bearing shoes may obtain bearing on the hole wall through a considerable distance—a distance long enough that the guide device, fitting the reamed hole rather snugly, must be aligned.
in very close accuracy with the axis of the hole in which it stands. A typical length of guide tube 30 is equal to one or more lengths of drill pipe—20 feet or more. And this tube 30 is also heavy enough to be relatively stiff and unbending. Due to the fact that it is of greater diameter than the drill pipe, it is stiffer than the drill pipe even if its wall be no thicker than the wall of the drill pipe, and the wall of tube 30 may be even thicker than the wall of the drill pipe so as to obtain maximum stiffness.

Where the guide device is to have only a guiding function, as in the form of assembly and structure shown in Figs. 1 and 2, it is preferably rotatably mounted upon the drill pipe, so that the guide tube need not rotate with the drill pipe but may stand relatively stationary in the hole. For this purpose the guide tube rotates at its upper and lower ends upon roller bearings 31, which roll upon the drill pipe section 22. To take care of end thrusts, end thrust ball bearings are provided, as indicated at 32. The bearing structure is shown in detail in Fig. 3 for the upper end; the structure is the same at the lower end of the guide tube as is indicated in Fig. 1.

Guide tube 30 is provided with a plurality of circumferentially spaced longitudinally extending rows of slots 33 in which are mounted the bearing shoes 34. As will be seen from an inspection of the drawings, these bearing shoes are arranged in longitudinal rows. In Fig. 3 some of the tube slots 33 are shown without shoes mounted in them, for better showing of the slots. The upper portions of the shoes may have overhanging end extensions 34a which are of such length that abutment adds to the general stiffness of the structure. On the other hand, these overhanging abutting ends are not necessary; and two shoes without such overhanging ends are shown at 34β in Fig. 3. The outer parts of the shoes project beyond the outer surface of guide tube 30; and, the shoes being arranged in spaced rows, the assembled formation is much like that of a fluted column, the rows of shoes forming the ribs and the spaces between the rows of shoes forming grooves. These longitudinal grooves, in the exterior surface of the assembled guide device, afford longitudinal passages for the circulation fluid which flows upwardly around the whole assembly, being forced down through the interior passages to the drill bit at the lower end. And the spaces between adjacent ends of contact shoes in each longitudinal row (whether the spaces are afforded by the contact shoes having no overhanging ends, or are afforded by a tapering of the overhanging ends as shown in the drawings) afford circumferential passages for the circulating fluid, so that the flow of circulating fluid upwardly around the guide device may be equalized all around it.

Each shoe 34 has a shank 36 which fits in and extends through the tube slot and which is undercut at both sides with grooves 37, best shown in Fig. 4. To hold the shoes in to the tube 30, key strips 38 extend longitudinally inside tube 30 between rows of shoe shanks and have their opposite edges entering the undercut grooves 37. Each of these strips may preferably extend the whole length of guide tube 30; and the cross-sectional arrangement may best be seen from Fig. 4. The ends of these key strips may abut the confining rings 39, the upper one of which is shown in detail in Fig. 3. These rings 39 may be force-fit into tube 30; and the rings thus serve to confine the key strips 38 longitudinally, while the key strips serve to space the rings 39. In the form now under discussion, where the guide device does not necessarily rotate with the drill pipe, the inner ends of shanks 36 do not contact with the drill pipe section 22. The detailed structure of one of the reamers is shown in Fig. 5. Each reamer embodies an exterior tube 30a and an interior tube 22a. These tubes are screw-threaded at their ends, and both are screw-threadedly joined to the head or coupling members 41, as will be understood from Fig. 5. The exterior tube 30a is provided with a circumferential row of longitudinally extending slots 33a, and the cutter blocks are mounted in these slots. These cutter blocks, designated by the numeral 34a, are, in general, in the form of bright tools, similar to the bearing shoes 34, and may carry cutting elements or cutting edges of any desired character. However, for most reaming purposes it is desirable to provide a roller cutter; and for the purpose of mounting such cutters the cutter blocks are recessed on their exterior faces, as is indicated at 43 in Fig. 5, and the blocks are also formed in two halves. The transverse division between the two halves is shown at 44 in Fig. 5. In the block recess 43 the roller cutter 45 is mounted on a spindle 46. The ends of this spindle are set in the opposite halves of the cutter block; and one end of the spindle is bent and set at an angle in the cutter block, as is indicated at 46a in Fig. 5. This angular setting prevents the spindle from rotating about its longitudinal axis and thus confines the wearing bearing surface to the rotation of the roller cutter 45 on the relatively stationary spindle.

Other than in special provisions for accommodating a roller cutter and being made in halves, the cutter blocks 34a may be similar to, or exactly like, the bearing shoes 34. These cutter blocks, like the bearing shoes, have shanks 36a which extend through the slots in tube 30a, and are undercut as indicated at 37a in Fig. 6, and the key strips 38a...
enter these undercuts and hold the cutter blocks in place in tube 30a. The key strips 38a are confined longitudinally between coupling heads 41. For the purposes of the reamer structure, in which it is of course desired that the cutters rotate with the drill pipe, and in which the outer tube 30a is secured to the coupling heads 41, the shanks 36a of the cutter blocks may, and preferably do, bear inwardly against the inner tube 22d. By so doing, the bending stiffness of the inner tube is added to that of the outer tube; so that the whole reaming structure becomes very rigid and strong.

The structure which I have described in detail in connection with Figs. 5 and 6 applies to both upper and lower reamers as shown in Figs. 1 and 3. The action of the assembly shown in Figs. 1 and 2 will now be understood. The reaming diameter of lower reamer 13 is preferably substantially the same as the maximum cutting diameter of drill bit 14. That reaming diameter may be the same or greater than the drilling diameter of bit 14, but should not be less. It is the function of lower reamer 13 to ream and round out the hole drilled by bit 14; and in order to do so it should be of reaming diameter substantially not less than the drilling diameter of the bit. The over-all diameter of the guide device 12 is preferably just slightly less than the reaming diameter of reamer 13, so that the guide device will enter snugly but not too tightly into the hole rounded out by the reamer. Entering thus snugly, and being stiff and unbending in its construction, and closely coupled with the reamer and with the drill bit, the guide device guides the drill bit and the reamer ahead along a straight course; resisting any forces which tend to deflect the bit or reamer from that course. In consequence, the bit drills a straight hole ahead and the reamer acts further to round out and straighten up the hole.

Furthermore, the drill bit is constrained against the usual gyration or wobbling so that it drills an initial hole which is more nearly round than is ordinarily the case.

The general function of upper reamer 11 is also to ream out the hole. For this office it may be of the same reaming size as reamer 13, which is a little larger than the over-all diameter of guide device 12. One of its main functions, however, is to ream upwardly ahead of the guide device in order to free the guide device for removal from the hole in case any obstruction or hole contraction is encountered on the way out. For such purpose reamer 11 has a reaming diameter at least as large as that of reamer 13, but it may have a reaming diameter larger than that of reamer 13. It is no objection if the upper reamer 11 reams out the hole above to a diameter larger than that of the hole in which the guide device fits; and such further enlargement of the hole is in some aspects desirable in that it makes the upward removal of the guide device more easy and free.

The structures of guide device and reamer which I have explained are seen to be very similar—so similar in fact that by slight modifications and substitutions of cutters for bearing shoes a single structural element may be made up which will perform both the functions of guiding and reaming. Such a structural element is shown in Fig. 7. Here two concentric spaced tubes are employed, the outer one shown at 30d and the inner one at 22d. Coupling heads 41 are used like those shown in Fig. 5; in fact the head and tube structure is the same as that shown in Fig. 5 except that the tubes are longer and are provided with longitudinal rows of slots. In these slots cutter blocks 34a are alternated with bearing shoes 34d. Cutter blocks 34a may be the same as those shown in Figs. 5 and 6, and the bearing shoes 34d the same as those shown in Figs. 3 and 4, excepting that the shanks of these shoes 34d, as shown at 36d in Fig. 8, extend inwardly to rest against the inner tube 22d. The bearing shoes and the cutter blocks are held in place by the key strips 38a, in the same manner as before described. The structure, formed as described, is very stiff and rigid. Through the medium of the coupling heads 41 it may be coupled into a drill string at any desired point, preferably immediately above the drill bit. The reaming diameters of the reaming cutters is preferably just slightly greater than the over-all diameters of the shoes; so that the shoes may fit snugly but not with tight friction against the wall of the hole. The device, as made up in this manner, forms a rigid guide for the drill bit, not only because of the bearing of the shoe against the well hole, but also because of the long extent of reamer contact with the hole wall. The bit and reamers are rigidly guided on a straight line and are rigidly held against gyration. And the single device as made up in the manner described performs a reaming and rounding out function as well as a guiding function.

As will be readily understood from what has been said, the disposition and alternation, or other relative placements, of shoes and cutter blocks in the structure of Fig. 7 may be varied by interchange of parts. I have illustrated an arrangement in which cutters and guide shoes alternate. But other arrangements or successions may be used. For instance, it may suffice that a circumferential row of reaming cutters be used at the bottom and at the top of the illustrated structure, and that all other intermediate members may be bearing shoes. And whatever may be the relative arrangement of shoes and reaming cutters, it is only necessary that the lowermost, or the uppermost and lowermost, set be reaming cutters; the lowermost set to ream.
ahead of the bearing shoes on the way down, and the uppermost set to ream ahead of the shoes on the way upward.

Thus, as a further variation, in the arrangement shown in Fig. 7 the two middle sets of rollers 45x may be plain surfaced so as to obtain a smooth rolling contact with the hole wall and thus become guides rather than reamers. In such case the rollers may well be of such diameters that they do not project radially quite as far as the cutter rollers—so that the over-all diameter of the roller equipped guides is substantially the same as that of the bearing shoe guides. In using the rollers as the guide contact members it may not, however, be so important to leave clearance, or so much clearance, as with the shoe type.

As the above paragraphs indicate, the structure which has been described is capable of varied uses by making substitutions. In any of the forms of assembly shown in the drawings, shoes, reamer cutters and bearing rollers may be substituted for one another; with various resulting assemblies of which those that have been described are illustrations.

I claim:

1. In combination with a drill stem section, a tube concentrically surrounding the section and mounted thereon, said tube having slots circumferentially spaced, wall contacting members mounted in the tube slots, said members having grooved shanks projecting inwardly through the tube slots, and longitudinally extending keys within the outer tube engaging said shanks, said cutters and shoes having shanks projecting inwardly through the tube slots, and longitudinally extending keys within the outer tube engaging said shanks and holding them against inward radial movement relative to said outer tube.

2. In combination with an inner tubular member, an outer concentric tube, means interconnecting the two tubes at their ends and maintaining them in concentric annular spaced relation, the outer tube having a plurality of longitudinal rows of slots circumferentially spaced, bearing shoes mounted in some of said slots, and reaming cutters mounted in other slots.

3. In combination with an inner tubular member, an outer concentric tube, means interconnecting the two tubes at their ends and maintaining them in concentric annular spaced relation, the outer tube having circumferentially spaced slots, and contact members mounted in the slots, said members having shanks projecting inwardly through the tube slots, and longitudinally extending keys within the outer tube engaging said shanks, said cutters and shoes having shanks projecting inwardly through the tube slots, and longitudinally extending keys within the outer tube engaging said shanks and holding them against inward radial movement relative to said outer tube.

4. In combination with an inner tubular member, an outer concentric tube, means interconnecting the two tubes at their ends and maintaining them in concentric annular spaced relation, the outer tube having circumferentially spaced slots, and contact members mounted in the slots, said members having shanks projecting inwardly through the tube slots, and longitudinally extending keys within the outer tube engaging said shanks, said cutters and shoes having shanks projecting inwardly through the tube slots, and longitudinally extending keys within the outer tube engaging said shanks and holding them against inward radial movement relative to said outer tube.